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The PC Dugout Micro-Mainframe Integration System: PAX Implementation

by
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This report describes the research and development of PC Dugout, a transparent software application for the distribution and control of applications on the Programming, Administration, and Execution (PAX) system. PC Dugout is designed to aid in the productive use of personal computers connected to PAX. The program enables previously centralized processing tasks to be distributed to personal computers, resulting in lower operating costs and improved user interfaces. PC Dugout automatically distributes and maintains personal computer applications developed to support the Military Construction, Army program.

The design of PC Dugout addresses the challenge of providing an efficient, reliable method for distributing and updating PC applications while exercising an effective level of system management for a group of users that constantly changes and possesses varying degrees of computer proficiency. PC Dugout employs a menu interface, takes advantage of the PC interface with which new Dugout users are already familiar, and transparently manages tasks for multiuser applications.

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FOREWORD

This research was conducted for the Programming Branch of the Directorate of Military Programs, Headquarters, U.S. Army Corps of Engineers (HQUSACE), under Work Unit OMA-CEMP-P-P7, "PC Dugout." The HQUSACE technical monitor is Mr. John Sheehey, CEMP-MP.

The work was performed by the Facility Systems Division (FS) of the U.S. Army Construction Engineering Research Laboratory (USACERL). The study reprinted in the Appendix was conducted by John Murphy and Associates, Phoenix, AZ. Dr. Michael J. O'Connor is Chief, FS. The USACERL technical editor was Gordon L. Cohen, Information Management Office.

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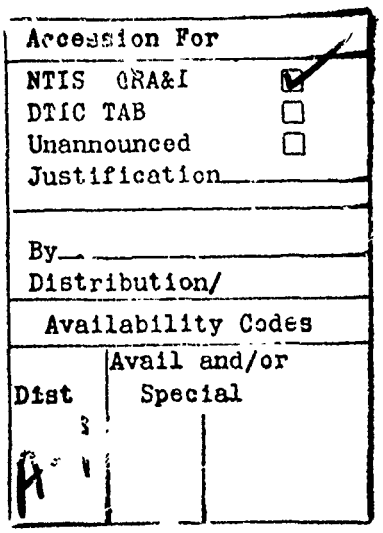

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1 INTRODUCTION

Background

This report describes the research, development, and implementation of PC Dugout, one of the applications on the Programming, Administration, and Execution (PAX) mainframe computer system. PC Dugout was designed to support the Army's goal of shifting selected processing tasks from the PAX mainframe to users' personal computers (PCs). This goal posed a number of technical and operational challenges described in Chapters 2 through 5.

PAX is a mainframe-based timesharing system developed by the U.S. Army Corps of Engineers (USACE) to support the Army's portion of the Military Construction, Army (MCA) program. Through the PAX system menu a number of applications are available to users, including the DD Form 1391 Processor, the Automated Multi-Year Plan Application Subsystem (MYPLAN), the Economic Analysis Package (ECONPAC), and the Construction Appropriation, Programming, Control, Execution System (CAPCES). These systems assist with the identification, planning, management, and approval of Army construction projects; they guide, control, and facilitate the review process throughout the chain of command.

The PAX applications are characterized by centralized, rather than distributed, databases. The central, shared databases provide geographically distributed users access to current, official Army documents and data such as DD Form 1391s and economic analyses. PAX applications also provide users standardized operating procedures, extensive data validation capabilities, and help in reducing errors.

With the current widespread availability of PCs and increased sophistication of PC software, the Corps of Engineers wants to more fully exploit users' PCs while lowering PAX computing costs. PCs offer a number of advantages over mainframe timesharing systems, including:

- lower operating costs
- quicker response to users
- improved user interfaces.

The data used by any one system user is composed of information entered into the system by many system users located all over the world and of every echelon of the Army (and other agencies). PC applications lack the capacity to support such an operation.

PAX applications cannot be moved entirely to PCs because that would require distributed databases, and local PCs cannot be dedicated to support distributed data. In addition, the applications themselves are not designed to use distributed database architecture. One of the primary purposes of PAX is to make available to system users, up-to-date information about the programming and budgeting of military construction sorted at the installation, MACOM, DA, and other levels. This is not achieved with distributed databases.

Objective

The system had to support worldwide distribution of applications in a manner transparent to users of differing levels of computer proficiency, and had to reliably assure that all users in the field are using the latest versions of the multiuser applications.

Approach

The best solution was to take advantage of the benefits of both mainframe and personal computers by linking preprocessing on PCs with central mainframe processing. PAX applications would then have software residing both on users' PCs and on the PAX mainframe. With this approach in mind, the next step was to establish criteria for the distribution of PAX/PC applications and related functions. Chapter 2 describes the specific requirements that were developed for PC Dugout.

Mode of Technology Transfer

PC Dugout is available for general use as a function of the PAX system. Users may obtain a PAX logon identification (ID or PAXID) by contacting Mr. Michael Rice at Headquarters, U.S. Army Corps of Engineers (HQUSACE), Directorate of Military Programs, Washington, DC, (202) 272-0577. PC Dugout is available as a subsystem to all PAX users. Once logged in with a PAXID a user is automatically registered for the PC Dugout subsystem. There is no software for the user to install; PC Dugout is installed automatically on the user's PC once the user requests the PC Dugout subsystem.

2 CRITERIA FOR DEVELOPING PC DUGOUT

The distribution of PAX/PC applications must meet certain criteria in order to fulfill the Army's requirements for efficiency, reliability, and ease of use. The PC Dugout operating environment is characterized by:

- hundreds of users, distributed worldwide
- large, centrally controlled, shared mainframe databases
- continually changing mainframe software and application requirements
- many applications, operating independently, that must be supported.

The following major requirements for PC Dugout were developed after a thorough analysis of the PAX environment and user needs.

Reliable Distribution of PAX/PC Applications

A reliable method had to be found to distribute PC software to PAX users. The software developed for this task must be robust—impervious to transmission or user errors—and should require minimum maintenance.

Ease of Use

Many users around the world access the PAX system daily. Most of these users are not computer-oriented and user turnover is high. Thus, ease of use was a fundamental necessity for any PAX application. PC Dugout procedures must be simple and easy to learn without a training course. PC Dugout should also be self-installing and have an on-line help facility.

Productive Use of PCs

PCs are now available to virtually all PAX users. It is highly desirable to take full advantage of this installed equipment. Along with distributing PAX/PC applications, PC Dugout should be used to improve communications between PAX users, to help users operate their PCs more effectively, and to promote the sharing of various PC techniques and knowledge among PAX users.

Cost Efficiency

PC Dugout must be cost effective and result in lower overall PAX processing, personnel, and maintenance costs. The software must be efficient and minimize processing and software fees by at least 20 to 25 percent of current operating cost. PAX/PC applications have a potential to reduce PAX system cost from 15 to 67 percent or more as compared to mainframe processes. Savings to the government from these procedures could amount to $1 million to $4 million per year as PAX system use grows. One application, PC-PAXMAIL is expected to save users between $300,000 to $500,000 in its first 12 months of use. It will be maintained by use of PC Dugout.

Multiple Application Tracking

PC Dugout will distribute multiple independent PC applications maintained by sponsors who issue updates at various times. Users, however, will only select PC applications pertaining to their jobs. PC Dugout must be able to track which applications are installed on each user's PC and who should be notified when an application is updated.

Identification of Users

The system must be able to identify and track each user and machine since the system will need to keep track of who has particular applications, and notify users when updates are required.

Distribution of Updates

PAX mainframe applications are often improved or modified due to changes in requirements and operating procedures. PC Dugout must distribute and install the updates to these mainframe changes as well as the applications themselves.

Verification of Proper Application Installation

PC Dugout must be able to verify that applications or updates have been successfully installed on a user's PC. To accomplish this, PC Dugout needs an automated checking mechanism that will, without user intervention, determine whether an application has been installed properly or not. A redundant checking mechanism was also required for periodically checking PC application files to insure that nothing has been destroyed or altered. In addition, the status of each application for each person should be tracked. This will assist in distributing revisions and identifying users with problems.

Security Features

The integrity of PAX applications and data must be maintained. PAX applications must have safeguards against the use of obsolete programs and data files. In addition, PC Dugout procedures need to address the threat of computer viruses.

Management of Users and Applications

The management of users and applications is critical in a distributed environment. The presence on the system of hundreds of users located throughout the world adds to the complexity of maintaining data and system integrity. PC Dugout needs a coordinator responsible for PC Dugout maintenance and coordination with system developers. The coordinator must also review and test all software and newsletters before their release. Applications must be tested for computer viruses and checked to see that all required user documentation is completed before release.

Reports should be available to both the PC Dugout coordinator and system developers that list all users for a particular application, and whether or not those users have successfully installed current software versions.

Coordination With Software Developers

PC Dugout must be easy for system developers to work with. There must be coordination between system developers and the PC Dugout coordinator for the timing and notification of software releases.

3 GENERAL PC DUGOUT FEATURES

After the requirements for PC Dugout were specified, the basic features of the application were constructed. The design for PC Dugout includes the basic capabilities described below.

PC Registration Function

The first time a particular PC is used to access PC Dugout, a registration process is initiated. Certain PC Dugout programs and files are automatically installed on the user's PC. From then on, PC Dugout maintains itself on the PC, automatically checking and repairing files each time the user enters the program. During the registration process users are asked to provide their name and address information; a unique PC-identification number is then issued to enable PC Dugout to track the user's applications.

Newsletter Function

This feature provides users information pertaining to PC Dugout, PAX/PC applications, and items of general interest to PC users. For example, newsletter articles may contain information on PAX/PC system enhancements and who to contact for assistance. Newsletters may also contain ideas and techniques that will help PAX users employ their PCs more effectively. Users can have a selected newsletter printed on-line immediately, or they can have a file containing the newsletter created on their PC.

Utilities Function

This function provides access to a library of PAX-related PC utilities. These fairly simple stand-alone utilities are a combination of text and PC programs that can help users with specific operations. For example, users can download utilities to pack (compress) and unpack files, sort directories, or automate log-on procedures. Descriptions of these programs and the programs themselves can be selected from a menu and copied automatically to a user's PC.

PAX/PC Application Function

The Application function is designed to distribute and maintain PC-based PAX applications that work with PAX mainframe applications. This function allows users to register for PAX/PC applications, and download and verify those applications. When the user has selected the desired PAX applications this function will automatically keep those applications updated. When entering PC Dugout, users will be notified if their applications are outdated.

Submit Function

The Submit capability enables a user to contribute PC software utilities or newsletter articles to the entire PAX user community via PC Dugout. This feature also enables users to send comments to the PC

Dugout coordinator. System developers submit PAX/PC applications to the coordinator via this function. The coordinator reviews and tests the software before it is released through PC Dugout.

Help Feature

Users need not remember procedures or continually refer to their user manuals because PC Dugout provides on-line documentation. A user may enter "HELP" in response to any prompt, and the system will respond with a description of the appropriate responses. This feature is designed to ensure the system's ease of use and minimize user support requirements.

Menu Interfaces and Automated File Transfers

To further insure PC Dugout's ease of use and reduce opportunities for user error, menu interfaces and fully automated file transfers were implemented.

PC Dugout's user interface consists entirely of menus. Users simply select the menu command they wish to execute. This takes them to another level of menus, where they select the desired action or item. Users do not have to remember any commands or language syntax. In some cases users are asked to answer a few simple, nontechnical prompts. To download or upload files, a user simply selects a command from a menu and answers one or two prompts. The PC Dugout menu structure is illustrated in Figure 1.

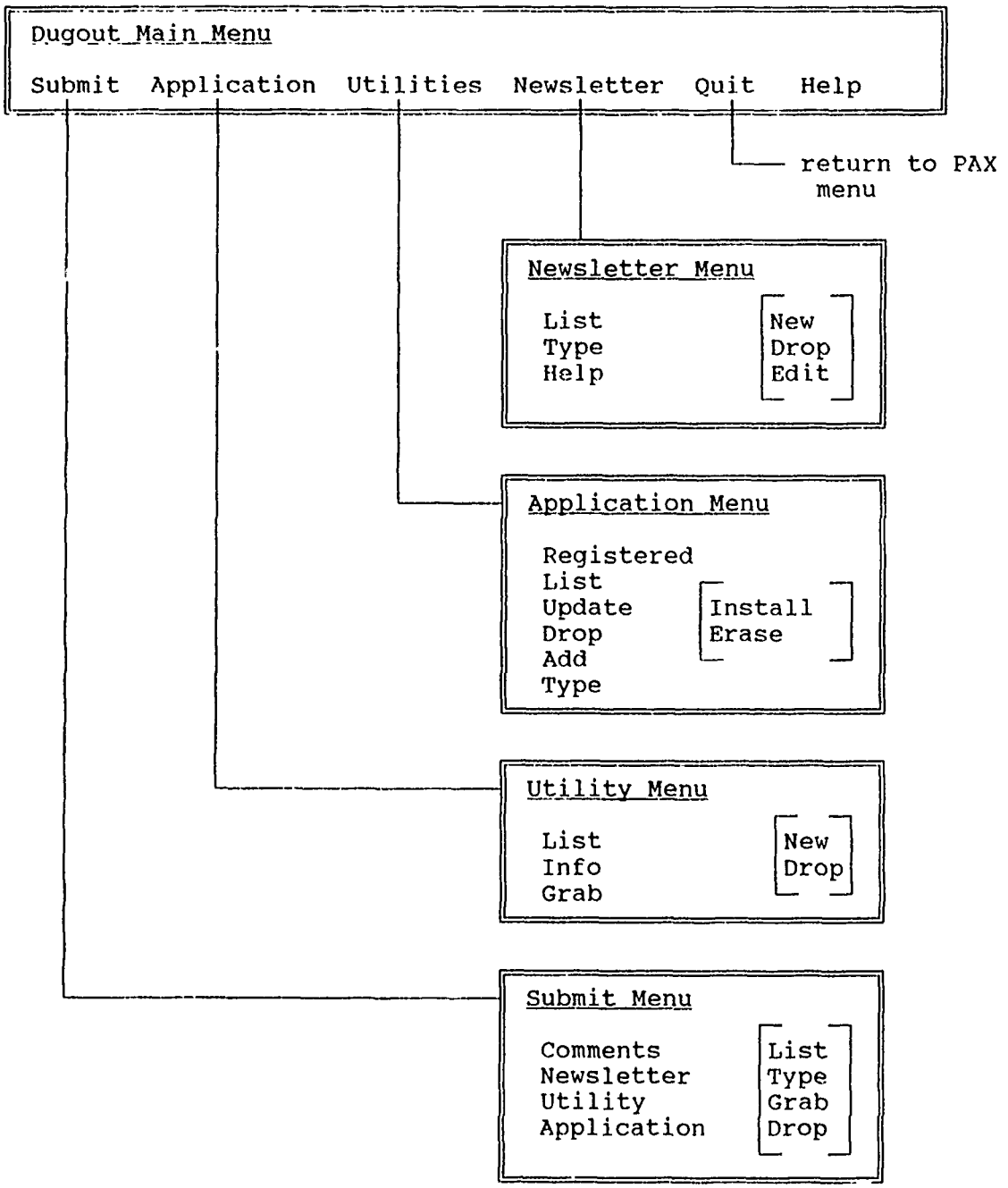
PC Dugout Coordinator

The PC Dugout coordinator (DC) manages the Dugout system. The coordinator has access to an expanded PC Dugout menu, which contains commands for executing administrative tasks such as releasing and deleting PAX/PC applications.

To protect users and data, all submissions (i.e., PAX/PC applications, newsletters, and utilities) are placed in a "pending" mode. The coordinator reviews all submissions before releasing them to users. Submissions are checked for viruses and integrity. The coordinator works closely with system developers to plan PC software release dates.

The coordinator also has access to a number of PC Dugout management reports that help provide insight into what users are doing. Data stored in the PC Dugout database can be presented in preprogrammed reports that include:

- lists of all users registered for a particular application, including PAXID, name, address information, phone number, and current application status
- mailing labels addressed to users registered for a particular application
- lists of users and whether or not their applications have been updated.



NOTE: Commands in brackets are for the exclusive use of the Dugout coordinator.

Figure 1. PC Dugout menu structure.

4 IMPLEMENTATION TOOLS

This chapter describes the requirements for the software tools used to implement PC Dugout and explains why certain software products were used. The PAX environment is also briefly reviewed.

PAX Mainframe Environment

The PAX applications operate in an IBM VM/CMS* environment. Users access the mainframe through an asynchronous dial-up network at data transmission speeds ranging from 300 to 9600 baud, with 1200 baud being most common. PC Dugout users are not permitted to directly issue VM/CMS commands—all PAX functions are made available to users through a main PAX menu presented at login. Each PAXID has a customized menu that includes only the applications and functions authorized for the ID. PC Dugout has been added to user's menus, allowing access to the PC Dugout application.

Selection of a Database Management System

PC Dugout operations require that multiple users be able to access and update the central mainframe database simultaneously. However, simultaneous read and write access to files is not supported directly by the VM/CMS operating system. CMS was designed as a single-user operating system, so its file access mechanisms do not support shared access to files. Database management system (DBMS) vendors have developed various approaches to solve the shared access problem. The database management systems Focus and Structured Query Language/Data System (SQL/DS) successfully circumvent this restriction in the PAX VM/CMS operating environment. Focus is the DBMS for most PAX applications, but its operating overhead would be excessive for PC Dugout. Therefore, SQL/DS was chosen for the implementation of PC Dugout. SQL/DS provides a relational database that can be used effectively by PC Dugout, and it provides significant operating efficiencies.

The design of SQL/DS places great emphasis on efficient data retrieval for multiple users. Retrieval techniques used include use of the most efficient access path to satisfy a request and extensive use of memory buffers. Because of SQL/DS buffering, some of PC Dugout's smaller tables may reside completely in random access memory (RAM). Retrieving data from such tables does not require physical disk accesses, and this results in dramatic improvements in both operating costs and system response tin ?.

Mainframe Implementation Language

Restructured Extended Executor (REXX) was chosen as the implementation language for developing mainframe PC Dugout because of its flexibility and ease of use. REXX is an interpreted language, which is ideal for development and prototyping since it requires no compilation step. Additionally, there is a REXX/SQL interface available that permits direct access to SQL data from REXX procedures. REXX was chosen over EXEC2 because it is less costly to use than EXEC2, and provides a structured language that is easier to code. It is also targeted by IBM Corp. to replace that company's EXEC and EXEC2 language processors, and is one of the products included under IBM's Systems Application Architecture

*VM/CMS is Virtual Machine/Conversational Monitor System.

(SAA). This is important because SAA is IBM's approach to developing applications that will be able to run on any IBM computer in the future.

PC Implementation Language

Some PC Dugout functions will be implemented on the PC and invoked from the mainframe. The C language was chosen for the development of PC Dugout programs because it is easy to code and maintain, and there are several suitable compilers available for the IBM PC. Programs written for PC Dugout can also be ported to other PC architectures if they are written in C.

Microsoft's QuickC compiler was chosen for development because it best fit the requirements of PC Dugout and features an interactive development environment. QuickC also generates small compiled modules that can be easily distributed from the mainframe. The programs can be recompiled later with the Microsoft Optimizing C compiler if further reductions in module size are required. QuickC does not require a run-time module so there are no fees or licensing restrictions. The compiled code executes quickly so resource-intensive PC Dugout programs do not create long delays.

Communications Package and File Transfer Protocol Requirements

The high degree of user friendliness and control needed in the PAX environment requires the automation of all PC Dugout operations on the PC. PC Dugout must be able to determine the status of a user's PC application and replace outdated files with minimal user interaction. Also, future enhancements may require even more automation, such as the updating of applications overnight without any intervention by the user.

Communications Package Requirements

Communications software requirements can be best met by a package that provides the following minimum capabilities:

- the execution of DOS (disk operating system) commands and PC programs under control of the mainframe application

- two-way file transfers initiated by the mainframe.

Tym/COMM (BT Tymnet) and VistaCOM (CDC), both supported in PAX, satisfy these requirements. ProComm, although widely used by the Army, is not appropriate for PC Dugout because it does not support the execution of DOS commands or file transfers under mainframe control. The Appendix reprints the findings of a study to determine which communications protocols and software packages should be supported by PC Dugout.

Tym/COMM and VistaCOM are currently used by PC Dugout so users will have a choice of communications packages and the Government is not the captive of a single vendor source.

The PC Dugout communications functions were implemented as a master-slave relationship controlled by the mainframe. This permitted the use of off-the-shelf communications programs and simplified the communications aspect of PC Dugout. In the future, extensions to PC Dugout may be

added to support a peer-to-peer communications interface in addition to the existing master-slave relationship. A peer-to-peer interface would facilitate offloading more functions to the PC. However, provisions have been added for other communications packages to access PC Dugout.

File Transfer Protocol Requirements

The transfer of files by PC Dugout from one computer to another requires the cooperation of both the sending and the receiving computers. The set of rules governing the file transfer is called a protocol, and the program that implements these rules is called a driver. Most PC communications packages have drivers that support several different protocols.

To be viable in the PC Dugout environment, file transfer protocols must have the following features:

- operation in the PAX environment (IBM VM/CMS and Tymnet)
- low-cost file transfers
- the ability to transfer both text and binary files
- the ability to transfer files without modification
- a corrective file transfer mechanism
- mainframe file compatibility with other protocol drivers.

The following subsections describe these criteria in more detail.

Operation in the PAX Environment. The protocols available for PC Dugout operations are limited to those for which IBM VM/CMS drivers are available. If there is no program available for the mainframe that follows the protocol conventions, the protocol cannot be used. In addition, the drivers must be able to use the Tymnet communications network. Drivers currently available within the PAX environment are COPYPC, Kermit, Vista, and XMODEM.

Low Cost File Transfers. As many as 12 separate PAX/PC applications, each containing many files, will be distributed and updated through PC Dugout. The applications and updates will be downloaded to many PAX users worldwide. Thus, it is imperative for any driver used in PC Dugout to provide relatively low-cost file transfers.

File Transfer in Both Text and Binary Formats. File transfer protocols used by PC Dugout must be able to transfer both text and binary files because PC Dugout requires both types of files to operate. Text files contain alphanumeric information in a form suitable for reading. The characters in these files are translated between ASCII and EBCDIC* so they can be used either on the PC or the mainframe. Binary files are typically computer program files, intended for use only on the PC. Archive files are special cases of binary files in which one or more files (either text or binary) are compressed and collected in a single file. Most PC Dugout application files are compressed into archive files for distribution; they are unarchived on the user's PC automatically. This operation saves disk storage space in PC Dugout and reduces the time and connect charges associated with file transfers.

File Transfers Without Modification. PC Dugout checks the validity of installed PC applications by calculating a cyclical redundancy check (CRC) value for each application file on the PC and comparing it with the proper CRC value downloaded from the mainframe. If the CRC values do not match, a correct

*ASCII is American Standard Code for Information Exchange; EBCDIC is Extended Binary-Coded Decimal Interchange Code.

version of the application file is downloaded to the PC. CRC computation requires PC Dugout to transfer an exact image of the file.

..t all file transfer protocols can accommodate this directly. XMODEM, for example, does not. All files transferred by XMODEM are sent in full 128-character blocks. Thus, a file originally 20 characters long will end up 128 characters long after it is transferred. It is possible for PC Dugout to avoid this problem if all application files are archived before transmission and unpacked later on the user's PC. The archive is not affected by the extra characters, and when the application files are unpacked, they will retain their original size and CRC values.

Corrective File Transfer. A corrective file transfer capability can detect and correct transmission errors such as those due to line noise. This feature is required for protocols used with PC Dugout to provide an acceptable standard of reliability for file transfers.

Mainframe File Format Compatibility. Any binary PC file moved to the mainframe with one protocol must be usable by all other protocol drivers. If a file is uploaded to the mainframe using XMODEM, for example, it should be able to be successfully downloaded to a PC with COPYPC. The PAX XMODEM and COPYPC drivers use compatible mainframe file formats. An option has been added to the Vista driver to use files compatible with COPYPC and XMODEM.

File Transfer Protocols Used With PC Dugout

Tym/COMM using COPYPC is currently used by PC Dugout and meets all file transfer requirements. VistaCOM has been implemented using XMODEM, which can meet PC Dugout's protocol requirements as well. Vista, a protocol designed for use with VistaCOM, will not be used in PC Dugout since the number of transfer charge units required by the VistaCOM driver to send or receive a file is much higher than either XMODEM or COPYPC. KERMIT cannot be used because it is expensive to run and its protocol overhead increases connect time considerably.

Mainframe PC Dugout has been designed in a modular fashion so all file transfers are performed by a single, low-level routine. This routine identifies the communications package currently in use and handles all details of the file transfer invisibly to the calling routines. This design structure is important because it isolates PC Dugout operations from the specific communications package being used. The modular structure will make it easier to integrate additional communications packages with PC Dugout in the future.

5 DUGOUT DESIGN

The main purpose of PC Dugout is the distribution and control of PAX/PC applications. Designing the portion of PC Dugout that accomplishes this presented the greatest technical challenges. This section describes in detail PC Dugout's primary design features, which include:

- how PC Dugout's mainframe and PC programs work together
- how PC Dugout keeps track of users
- how applications are maintained on the PC.

PC Dugout Mainframe and PC Programs

PC Dugout functions are divided between the PC and mainframe based on the strengths of each environment. The primary interaction between the PC and mainframe consists of the mainframe issuing commands and controlling the transfer of files. A central master database, which is used for control and distribution functions, is implemented on PAX. This central database is used to track users, applications, and application status information. It also forms the basis for administrative reports and user mailing lists.

Other functions are supported on the PC, and are invoked by the mainframe through the Tym/COMM communications package. The PC supports functions that run best on the PC, such as data-editing routines, testing the status of applications installed on the PC, and generating status reports used to update the central database. The results of PC commands are placed in files and transferred to the mainframe, where they are interpreted.

Some of Dugout's PC functions can also be run in a stand-alone fashion, without a connection to PAX. When stand-alone operations affect data stored in the mainframe database, the changes are recorded on the PC and transmitted to the mainframe the next time PAX/PC Dugout is accessed. An overall diagram of PC Dugout components is shown in Figure 2.

PC Dugout Registration

Users gain access to PAX with PAXIDs, which are used for user control and billing purposes. Through a menu system, each PAXID is allowed access to a group of applications within PAX. PAXIDs may be shared by several people in an office or a building. Some users may have several PAXIDs, for development or other purposes. Similarly, some users may share PCs while others have access to multiple PCs. Network environments are common in larger offices. Since there is not a one-to-one correlation in the number of PAX users, PAXIDs, and PCs, user information and PAXIDs do not provide all information necessary to track PC applications installed by PC Dugout. Instead, PC Dugout tracks the registered PCs because the applications are linked to specific PCs.

When a user selects the PC Dugout option from the PAX menu for the first time, the user is required to register his or her PC before further access is permitted. When a PC is registered in PC Dugout, the user's name, address, and PAXID are entered in the SQL database. A unique PC identification number is generated and assigned by PC Dugout, and files are installed on the machine.

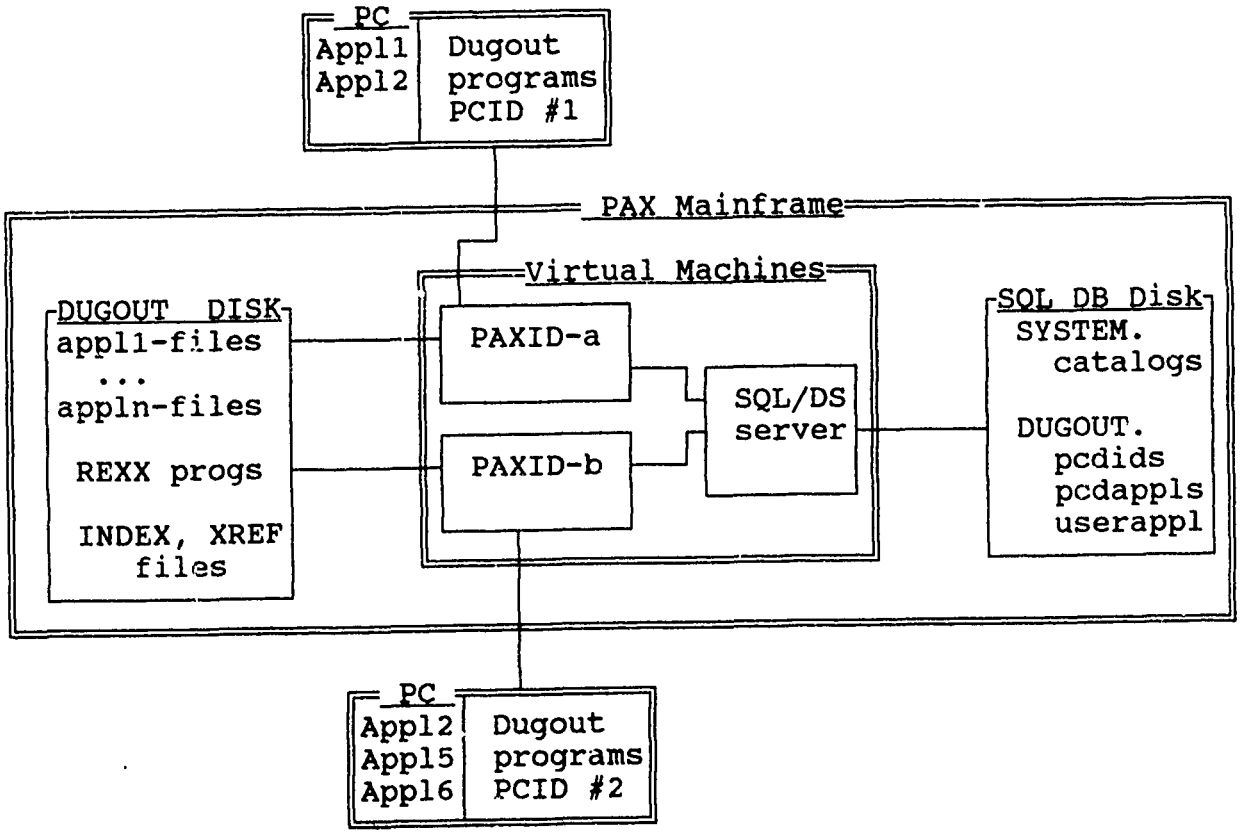


Figure 2. PC Dugout components.

The files installed include:

- an identification file containing the PC Dugout identification number (PCDID), user name and address, and installed application information

- an index of PC Dugout programs with CRC values of the correct files so the validity of PC Dugout PC programs can be checked

- PC Dugout PC programs for stand-alone operation and for use by PAX/PC Dugout (including programs to check the status of an application for the mainframe, edit address information, and create and use archived files).

A directory is created to hold these files and provide a uniform filing environment for PC Dugout operations.

When a registered PC is used to access PC Dugout, the identification file is copied to the mainframe to identify the PC in use and update the mainframe database with any new address or application information. The mainframe then initiates a check of the PC Dugout programs to ensure that they are all current. If any files are missing or require revision, the latest version of the PC Dugout program is moved to the PC. After the PC Dugout application itself has been verified, the user's identification file is examined to determine the current status of installed applications, user address, and items requiring the

user's attention within PC Dugout. Information is extracted from the SQL database and checked to see if there have been updates to the mainframe version of each application since the current user last checked. The user is then informed of any applications that require updates.

This approach prevents applications from being installed more than once on each PC even if the PC is shared. Additionally, if a user has several PCs, each PC can be tailored individually to match the operations of the user. A particular application need not be installed on each machine. For network environments, the network administrator will be responsible for registering the server and ensuring that the network has the most recent version of each application installed.

The Machine Identification Table

Each registered PC is assigned a record (row) in the Machine Identification Table in the SQL/DS database. The items (columns) recorded are described in Table 1. The entire record is devoted to user information. It contains no applications or application status columns.

Application Identification

PC Dugout distributes and maintains multiple, discrete PC applications. These applications consist of files that are downloaded to users' PCs. To distribute an application through PC Dugout, system developers must submit all program files, user documentation, and data files required by the application. System developers must also submit the following application information:

- the application name
- a short application description for use in PC Dugout's application menu
- a one- or two-page text description of the application
  a version number to help PC Dugout keep track of revisions.

The Application Index File

As part of the submission process, PC Dugout generates an application index file that contains the filename, number of characters, and CRC code of each file in the application. There are two record types in an application index file. The APPL record contains the application name and version number. FILE records contain the PC filename, number of characters in the file, and CRC code for the file. There is a FILE record for each file in the application.

Once the index file has been generated, a CRC value is calculated for the index file itself. The index file CRC is not stored as part of the index file because editing the file to include the CRC value would change the value of the index file's CRC. Instead the index file's CRC value is stored with application data in the Application Database Table described in the following section.

Computing the index CRC value provides a way to ensure that PC Dugout is using the proper index file when checking the application files. The index file cannot be changed by the user because an invalid index file is automatically replaced by the mainframe. A sample application index file is shown in Figure 3.

Table 1

Machine Identification and Registration Items

PCDID—A unique integer that identifies the PC record. This field is used to identify the user's PC and to link user information with other database tables. That is, PCDID is used as an external key in join operations. This field cannot be updated by the user.

PAXID—The PAXID used in registering the user's PC. This is the PAXID that has PC DUGOUT as an option in the main PAX menu, and helps to identify the user associated with this PC. The field can be updated by the user along with other address information.

MAILID—The PAXID that is to receive PAX Mail messages. It is normally the same as the PAXID field, but can be changed by the user.

FDATE—The first date this PC was used to access PC Dugout (registration date). It is not changed by the user.

LDATE—The last date this PC was used to access PC Dugout. It is updated automatically as part of the identification procedure.

FNAME, LNAME—These fields are used to record the user's first and last names. Two fields are used to allow the sorting of administrative reports by last name.

CITY, STATE, ZIP—These fields are used to record postal address information. They are broken out to facilitate selection of users and reports.

ADDR1, ADDR2, ADDR3—These are additional address lines to be used in conjunction with CITY, STATE, and ZIP.

PHONE—The user's telephone number with area code.

```
APPL TEST 2.20
FILE PCDCHECK.C          8102 DE7E
FILE CRC16.H             2592 E564
FILE HEXINT.H             742 B1E3
FILE CHECKFIL.H          1151 F835

                         - - - - - -
```

There are two record types in an application index file. The APPLication record contains the application name and version number. FILE records contain the PC filename, number of characters in the file, and CRC code for the file. There is a FILE record for each file in the application.

Figure 3. Sample application index file.

The Application Database Table

PC Dugout uses a database table—the Application Table—to keep track of all current applications. The types of data included in an application record are shown in Table 2.

Application Registration

Users may view a list of all applications available through PC Dugout and may register for any of them. When a user registers for an application, PC Dugout adds a record in the mainframe User-Application Table which contains the user's machine ID, the application name, and the user's application status. The status is first set to indicate that the application has not been installed since the program files have not yet been moved to the PC. The application directory is then created on the PC and a copy of the application index file is transferred to the PC.

At that point there are two methods available to complete the installation process: the files may be downloaded from the mainframe or loaded into the directory by the user from a distribution diskette. When the files have been moved to the proper location, the application status on the mainframe can be updated by entering the command that verifies applications. This procedure compares the calculated CRC code for each application file on the user's PC against the value recorded in the application index file. If all files are correct, the mainframe status is cleared, indicating the application has been successfully transferred.

A record is maintained in the SQL/DS database for each installation of an application on a PC. This record contains the current application status and provides a link to user and application information. The status field is updated each time the application is checked on-line. When a new application version is released by the PC Dugout coordinator, all registered users are flagged to indicate that revisions are necessary. The data elements in the User-Application Table are listed in Table 3.

Application Verification and Distribution

Users can check the validity of their PAX/PC applications by selecting the validation (Update) option from the PC Dugout Application Menu. Users must select this option to complete the process of installing or updating an application on their PC. After the user selects the application to check, the mainframe invokes the application validation program (which resides on the user's PC). The Update program uses the application index file, described previously, to test the status of an application's files. CRC values stored in the index file are used to check an application's individual files. When the mainframe invokes the validation program, the following information is also supplied:

- the filename of the index file to be used
- the index file's CRC value
- the PC subdirectory in which the application was installed.

The validation program is written in C, and checks over 8000 characters per second on a 4.77 MHz PC, the slowest machine likely to be used. This allows an application of a half-million bytes to be completely tested in about 1 minute. Newer, faster machines take even less time to validate applications.

Table 2

Application Table
(DUGOUT.PCDAPPLS)

APPLNAME—An eight-character application name. It must be unique, as no two applications are permitted the same name. Additionally, two different versions of the same application cannot be distributed under the same name.

APPLVER—A floating point number (two digits and two decimal positions) to identify which version of the application is being distributed. When this number is changed, all users registered for the application are flagged as out-of-date.

APPLDESC—A 40-character short description of the application.

PAXID—The PAXID used by the system developer.

APPLDATE—The date that the current version of the application was released to user

APPLCRC—The calculated CRC result for the application index file. This is used to ensure the correct index file is used to check all files.

APPLCOUNT—The total number of files comprising this application.

Table 3

User-Application Table Items
(DUGOUT.USERAPPL)

APPLNAME—The name of the application supported by PC Dugout.

APPLVER—The version number of the application installed on the PC.

PCDID—The identification number of the PC the application is installed on.

UADATE—The date the application was last verified on the PC.

VERDATE—The date the application was last modified in PC Dugout.

UASTATUS—The application status as of the last verification.

APPLDISK—The PC Disk in which the application is installed.

APPLDIR—The PC Directory in which the application is installed.

File Validation Methods

The validation of each file in an application by the Update program has two major functions:

- to find out if the required file exists
- to find out if the contents of the file are correct.

DOS provides functions to determine if a file exists. For files that are not critical to the integrity of an application, these DOS functions may be sufficient. A user may have a file with report headings to be customized with the installation's name and address, for example. In this case, the file is not critical; the system is primarily interested in the fact that the file exists and contains data. The procedure for verifying this is relatively straightforward since the capability is built into DOS.

The determination of a file's contents presents more of a challenge because DOS has no built-in ability to accomplish this. Several approaches are possible. One can either test attributes associated with the file, or test the contents of the file directly. Testing attributes can be faster but it is not as accurate.

One attribute that can be tested is the size of a file. This is not a very satisfactory test because many data files remain the same size even when the contents are changed. For example, 20 quarters of economic inflation factors will always remain the same size regardless of the values for the factors.

Date/Time stamps are another attribute that can be tested, but this approach requires files to be installed on the PC with a specific date/time stamp. This field can be changed by programs that write to the file or by utilities that can "fool" PC Dugout into accepting old or modified versions of files.

Checksums provide an approach in which the actual contents of a file (as opposed to the attributes) are tested. This method requires the file to be opened and read as a string of data. The character values are added together and a final sum is produced that can be used for comparison. Unfortunately, this approach does not detect all changes For example, a file containing the data value "1.0" could be changed to "0.1" without altering the checksum. This approach does not provide enough protection to assure the integrity of Dugout.

CRC checkvalues provide an improved alternative to checksums. CRC values have been used historically in modems and disk drives to detect errors in character streams. The CRC uses a division process and modulo-2 arithmetic on the character stream to calculate a checkvalue. The calculation of the CRC is sensitive to both the characters making up a file and the order in which they occur. A 16 bit CRC checkvalue is used, which is expressed in PC Dugout as 4 hexadecimal digits (0000, 1BA7, etc.). Using a CRC value provides assurance that no deviations, accidental or otherwise, occur anywhere in the file.

The CRC algorithm used by PC Dugout does not take significantly longer to compute than a checksum. Each character checked is used as an index in a table of combining values. These combining values are then XOR'ed with the previous CRC accumulator, avoiding the need for time-consuming divisions or bit rotations.

As mentioned earlier, a CRC value is computed for each application file when the application is installed in PC Dugout. This value is later compared to the values computed on user's PCs. A special CRC value of 0000 is used for files whose contents are unimportant to the integrity of Dugout.

The Validation Report

The validation program generates a validation report containing several record types that are processed by the mainframe. These records supply the name of the application being tested, where it is installed in the user's machine, the amount of disk space available, which version of the PC Dugout verification program was used to generate the report, and status information for the individual application files. Information listed for each file in the application includes:

- the PC filename
- the number of characters the file should have
- the number of characters actually found in the file
- the correct CRC for the file
- the calculated file CRC.

A sample validation report is in Figure 4.

This validation report contains several different record types:

- CHECK indicates the version of the PC Dugout program that generated the report

- CDIR shows the current directory of the application on the user's PC

- DISK shows the amount of free disk space on the indicated drive—values listed are the sector size, number of sectors per allocation unit, number of free allocation units, and the number of allocation units currently in use

- INDEX lists the index file name used to check the application, followed by the index file CRC code

- APPL is a copy of the application record supplied from the application index file (Figure 3)

- FILE lists file information for each file in the application, including filename, number of characters and CRC code from the application index file, and the number of characters and CRC code calculated for the user's file.

Each record begins with a status code that indicates the success or failure of the processing associated with the record. For example, PC Dugout will indicate a missing index file by setting the status code to 2. A file with the incorrect CRC will be given a status code of 1. A status code of 0 indicates successful completion of the operation.

Determination of Files To Update

When the validation report is completed, a copy is transferred to the mainframe. The mainframe reads the report, evaluates the status of the application on the user's PC, and uses the results to revise the User Application Table in the mainframe database. The mainframe then determines what additional actions should be taken. If the application index file is either incorrect or missing, a new index file is moved to the user's PC and the validation is repeated once. If any file is missing or incorrect, and fails the CRC test, it is added to a list of PC files that need to be replaced. Two running totals are kept: one

```
0 CHECK 0.03
0 CDIR D:\TEST
0 DISK D:  512    8   87     2293
0 INDEX D:\DUGOUT\TEST.IDX 1030
0 APPL TEST 2.20
0 FILE PCDCHECK.C          8102  DE7E      8102  DE7E
0 FILE CRC16.H             2592  E564      2592  E564
0 FILE HEXINT.H             742  B1E3       742  B1E3
0 FILE CHECKFIL.H          1151  F835      1151  F835
```

Figure 4. Sample validation report.

of the number of characters in the obsolete files, and the other of the number of characters in the correct files.

The information from the validation report is combined with another PC Dugout file on the mainframe, the CMS cross-reference file. For each PC file in the application, the cross-reference file provides the name of the CMS file in which it is stored by PC Dugout and an estimate of how long the file will take to transmit at 1200 baud. Figure 5 contains a sample CMS cross reference file for the TEST application.

Determination of Disk Space

A check is made to find out if the user has enough room on his PC to install all of the files that need replacement. The total free disk is added to the total size of all incorrect files. This is the amount of space available for the update. The total size of the replacement files is then compared with the total space available to determine if sufficient room is available on the user's PC.

Validation Summary Report and File Transfer

When all the above information is collected and the total number of files requiring replacement is determined, the user is presented with a report. The report contains summary information, including application name, date checked, and the number of files in error. If no files are incorrect, the user is informed that there are no files to fix, and the validation process is completed.

If there is not enough disk space on the PC, the user is issued a message to that effect and the installation process stops. If there is enough disk space, the user is told which files will be replaced and is given an estimate of the total time required to transmit the files to his PC (based on the current baud rate and the time originally required to load the file to the mainframe). The user is then asked if he or

```
4
@TEST GRPF0001@PCDCHECK.C@ A@50
@TEST GRPF0002@CRC16.H@ A@17
@TEST GRPF0003@HEXINT.H@ A@10
@TEST GRPF0004@CHECKFIL.H@ A@12
```

NOTE: The CMS cross-reference file is created on the mainframe when an application is submitted. The first record is used to keep track of a counter used in generating CMS names for application files. This record indicates the last sequential number used in creating a filename for this application. The remaining records list the mainframe CMS filenames of each file in the application, the associated PC filename, the type of file, and the number of seconds to transfer the file at 1200 baud.

Figure 5. Sample CMS cross-reference file.

she would like to proceed with the file transfer. If the user agrees, the file transfer is initiated using theprotocol that matches the user's communications package. Alternatively, the user may decline the transfer and complete it at another time, or load the files from diskette. A sample validation terminal session, including a validation summary report, is shown in Figure 6. Items requiring user response are underlined.

Local Operations

Most PC Dugout activities are performed under the control of the PAX mainframe. This is necessary to keep the PC Dugout central database current. However, two operations available through the menu system can be performed locally as stand-alone applications on the PC without accessing the PAX system.

The first of these stand-alone operations is a program that permits the user to update name and address information using a full-screen format. This operation rewrites the PC Dugout identification file, which is used to update the SQL machine identification table the next time the PC Dugout option in PAX is selected by the user.

The other program designed for local operation is an application update procedure that can reduce the cost and delay of downloading files over telephone lines. It is similar to the application verification procedure used by the mainframe, but differs in some important ways. This program prompts the user for the name of the application that needs to be verified or updated. The procedure then looks for the appropriate application index file on the PC and uses it to examine the application. Since the mainframe database is not accessible when the PC is logged out of PAX, this program has no way to verify that the index file is correct or to check the current version of the application. Also, instead of generating a report to be used by the mainframe, it presents the information directly to the user. If files are missing or the CRCs do not match, the user is prompted for a disk path for the proper files. This permits the user to

```
Enter command: Registered List Update Drop Add Type or Quit
>u

 Registered Applications
 #  Status  Name     Ver.  Directory
--- ------ -------- ----- --------------------
  1      0 TEST      2.20 D:\TEST
-----------------------------------------------
  Select application numbers (1 to 1):
>1
Now checking application TEST     1030 D \TEST

Now verifying TEST files. D:\DUGOUT

 445 BYTES, 17 SECONDS, 26 CPS

Index file and CRC are: D:\DUGOUT\TEST.IDX 1030
Processing results of application verification
+-----------------------------------------------+
 Application: TEST
 Version    :
 Directory  : D:\TEST
 Verified on: 12 Jul 1989 05:19:02
 Status     : OK

  Files in application  : 4
  Total application size: 12587

Total space available on disk D: 409600

No errors found to fix

Enter command: Registered List Update Drop Add Type or Quit
>
```

Figure 6. Sample application validation.

insert a distribution or backup diskette and automatically regenerate the files. The final results of this operation are noted in the PC Dugout identification file, which is used to update the mainframe database when the user next accesses PC Dugout through PAX.

This local approach to applications updating can be used to reduce time and money spent downloading application files over phone lines, especially if several PCs in an office are used for the same application. After this procedure, all the user has to do is access PAX and have PC Dugout verify that the application is properly installed. This followup serves as a double check for the users while informing the central database of the application's status on the user's PC.

Additional local PC Dugout operations may be added in the future to further reduce the cost of mainframe processing and enhance user interfaces.

Application Distribution Test and Cost Analysis

PC ECONPACK, one of the Army's required economic analysis software products, was used to test the distribution capability of PC Dugout. PC ECONPACK's user base consists of 1000 sites worldwide, all of which have access to the PC Dugout subsystem via Tymnet and PAX. The initial distribution of PC ECONPACK is done on a set of six low-density diskettes. The cost incurred per distribution site is calculated to be $80. The breakout is shown in Table 4.

The total manual distribution cost of $80,000 is incurred each time a new version is slated for release. With two updates a year, the price of distributing PC ECONPACK is $160,000 annually.

The cost to distribute the same application using PC Dugout is not only lower in absolute terms, but more cost-effective as well. The total PC ECONPACK application consists of 1.7 million bytes of information, compressed to 1.2 million bytes to reduce the transfer time. The cost to distribute PC ECONPACK to 1000 user sites was calculated at $72,000 by Huntsville Division, which is responsible for the distribution of PAX applications and administration of PC Dugout. The real savings are realized when an update is needed because, when distributed on line by PC Dugout, it is not necessary to transfer the entire application—only selected parts that have been updated. By design, PC Dugout can be applied

Table 4

Cost Per Each PC ECONPACK Distribution

Materials:	
Set of six diskettes at $0.75 per diskette	$ 4.50
Contracted duplication at $1.50 per diskette	$ 9.00
Mail cost per 6 disk set	$ 3.50
Office supplies	$ 3.50
Labor (at $12 per hour):	
Preparation of instructions (15 min)	$ 3.00
In-house reproduction cost per set (15 min)	$ 3.00
Assemble complete package (20 min)	$ 4.00
Accomplish mailing	$ 1.50
Installation at user site (2 1/2 hr)	$30.00
Hotline support (1 1/2 hr)	$18.00
Manual Distribution Cost per set:	$80.00
Distribution Cost for 1000 users:	$80,000.00

to update a previously distributed application after the fact. The feature allows the applications developer to use a combination of traditional distribution routes and/or PC Dugout. In this way all of the labor charges listed above, with the exception of hotline support, are eliminated.

6 CONCLUSION

This report has described the investigation, technical challenges, and development of PC Dugout, a transparent communications software capability for use in the PAX system environment. PC Dugout is designed to increase productivity by enabling previously centralized processing tasks to be accomplished by local PCs. PC Dugout is a user-friendly system that provides an efficient, reliable method for distributing and updating PC applications transparently while exercising an effective level of management to protect the integrity of the system. PC Dugout reliably makes sure that users of PAX applications are using the most current versions of these applications, thus ensuring that information provided from the field is consistent in substance and presentation.

APPENDIX: AN EVALUATION OF PC COMMUNICATIONS PACKAGES FOR USE WITH DUGOUT

I Introduction

The Programming, Administration, and Execution (PAX) system is an extensive Army data processing system serving hundreds of users worldwide. Traditionally, PAX has consisted of several large mainframe-based applications. With the advent of personal computer (PC) technology, some PAX applications are being ported for personal computers. PC Dugout was designed to automate the distribution and maintenance of these PAX PC applications.

Tym/COMM was the first PC communications package supported by Dugout. As support for other communications packages was desired, Tym/COMM was evaluated and compared with two additional candidates—VistaCOM and ProComm. The results of that analysis are described in this Appendix.

The analysis was divided into two major areas. First the communications packages themselves were evaluated for their suitability in the Dugout environment. Then the file transfer protocols used by these communications packages were analyzed to determine their cost of operation and compatibility with Dugout.

This appendix is organized as follows:

- Section II describes the Dugout operating environment.
- Section III lists the Dugout requirements for communications packages
- Section IV lists the Dugout requirements for file transfer protocols
- Section V evaluates the XMODEM, Kermit, COPYPC, and Vista file transfer protocols. (Results of cost-performance benchmark tests are included as an addendum to this Appendix.)
- Section VI contains product summaries for Tym/COMM, ProComm, and VistaCOM, including recommendations.

II Dugout Overview

Dugout is a timesharing application available through the PAX system menu. PAX uses an IBM mainframe running under VM/CMS, and utilizes the Tymnet communications network. Dugout currently supports IBM PC compatibles.

Dugout is primarily a file distribution mechanism. It installs and updates PAX PC applications on remote PCs. Dugout is a mainframe application, but some Dugout routines are downloaded to a user's PC when that PC is registered on Dugout.

Dugout tracks both registered PCs and applications. Applications consist of a group of files that comprise the application, plus an index file that identifies the proper version of each individual file in the application. Applications can be installed only on registered PCs. This installation process tracks the

application. Applications can be installed only on registered PCs. This installation process tracks the version and status of each application on each PC.

Dugout Operation

The status of a user's PAX PC application is checked by running a PC procedure that was downloaded when the user's PC was registered on Dugout. The results of this PC procedure are then uploaded to the mainframe and interpreted. Any files in need of update or replacement are transferred over the network to the PC.

To save transmission costs and reduce the amount of mainframe disk storage required, Dugout packs (compresses) most (but not all) application files into archives, which are binary files. Once an archive has been transferred from mainframe to PC, Dugout issues a DOS command to unpack the archived file, placing the new file in the proper directory on the proper disk. The archive is then erased. It is imperative that this operation be completely automated for accuracy and user convenience.

Because ease of use has been a primary design consideration in Dugout, the user interface was implemented as a series of menus rather than via the DOS command line. All operations are available to users as menu choices, and the file transfers and application validations are performed automatically, without requiring user intervention.

III Communications Package Requirements

As described in Section II, the high degree of user-friendliness and control needed in Dugout requires the automation of all Dugout operations on the PC. Users must be able to have an application's status checked, and outdated files replaced on their PC without entering additional commands. Also, future enhancements may require additional automation, such as updating applications overnight, without any intervention by the user. In order to achieve this level of automation, communications packages must be integrated into Dugout. This requires that the packages:

- permit the execution of DOS commands or PC programs under the control of the mainframe application
- support bidirectional file transfers initiated by the mainframe.

The communications packages were analyzed and evaluated in terms of how well they meet these two primary requirements (see Section VI).

IV File Transfer Protocol Requirements

Dugout must transfer files from one computer to another. The transfer of files requires the cooperation of both. The rules for file transfer followed by each unit are collectively called a protocol. The program that implements these rules is called a driver. Most PC communications packages have drivers that support several different protocols.

To be viable in the Dugout environment, file transfer protocols must include have the following features:

- operation in the PAX environment (IBM VM/CMS and Tymnet)
- low-cost file transfers
- the ability to transfer both text and binary files
- the ability to transfer files without modification
- a corrective file transfer mechanism
- mainframe file compatibility with other protocol drivers.

The following sections describe these criteria in more detail.

Operation in the PAX Environment

The protocols available for Dugout operations are limited to those for which IBM VM/CMS drivers are available. If there is no program available for the mainframe that follows the protocol conventions, the protocol cannot be used. In addition, the drivers must be able to use the Tymnet communications network. Drivers currently available within the PAX environment are COPYPC, Kermit, Vista, and XMODEM.

Low-Cost File Transfers

As many as 12 separate PAX-PC applications, each containing many files, will be distributed and updated through Dugout. The applications and updates will be downloaded to hundreds of PAX users worldwide. Thus, it is imperative for any driver used in Dugout to provide relatively low-cost file transfers.

Transfer of Both Text and Binary Files

File transfer protocols used by Dugout must be able to transfer both text and binary files since Dugout requires both types of files for operation. Text files contain alphanumeric information in a form suitable for reading. The characters in these files are translated between ASCII and EBCDIC so they can be used both on the PC and the mainframe. Binary files are typically computer program files, which are not intended for people to read. Archive files are a special kind of binary file in which one or more files (either text or binary) are compressed and placed in a library file.

Most Dugout application files are compressed into archives for distribution, and unarchived on the user's PC automatically. This operation saves disk storage within Dugout, and reduces the time and connect charges associated with the file transfers.

File Transfers Without Modification

Dugout checks the validity of installed PC applications by calculating a CRC value for each application file on the PC, and comparing it with the proper CRC value stored on the mainframe. If the CRC values do not match, a correct version of the application file is downloaded to the PC. The CRC value computation requires that an exact image of the file be transferred.

Not all file transfer protocols can accommodate this directly. XMODEM, for example, does not. All files transferred by XMODEM are sent in full 128 character blocks. Thus, a file originally 20 characters long will end up having a length of 128 characters after it is transferred. The file will then have a CRC value different from the proper CRC value stored on the mainframe.

Corrective File Transfer

A corrective file transfer capability can detect and correct transmission errors such as those due to line noise. This feature is required for protocols used with Dugout to provide an acceptable reliability standard for file transfers.

Mainframe File Format Compatibility

Any binary PC files moved to the mainframe with one protocol must be usable by all other protocol drivers. That is, if a file is moved up to the mainframe using XMODEM, for example, it should be able to be successfully downloaded to a PC with COPYPC. The PAX XMODEM and COPYPC drivers use compatible mainframe file formats. An option has also recently been added to the Vista driver to make its files compatible with COPYPC and XMODEM.

V Evaluation of File Transfer Protocols

This section summarizes the capabilities of XMODEM, Kermit, COPYPC, and Vista. The results of six cost-performance benchmark tests of the protocols are included in the addendum to this Appendix.

XMODEM

XMODEM is a public domain protocol designed primarily for PC-to-PC file transfers. XMODEM is used widely, and most PC packages on the market today support XMODEM file transfers. XMODEM transfers require use of the full 8-bit character set, a requirement not satisfied by all timesharing computer networks. Tymnet, however, does permit 8-bit operation.

XMODEM also transmits fixed 128-character packets, and requires an acknowledgment for each packet transmitted before the next can be sent. This subjects the transfer to network and host delays, which seriously degrade the effective character transmission rate. Even though it sends fewer characters than the other methods studied, it actually takes longer to transmit equivalent files.

Also, as noted previously, the fixed 128-byte blocks modify the file being transmitted. It is possible for Dugout to get around this problem if the application files are archived before transmission and unpacked later. This causes the archive file to grow to the next higher multiple of 128 characters, but has no effect on the archive. When the application files are unpacked, they retain their original size and CRC values. If XMODEM is supported as a file transfer option within Dugout, all application file transfers must be performed using archives. This would require a small change in certain procedures used in the Dugout prototype.

Kermit

Kermit is a public domain protocol used with other Kermit communications programs on mainframes and PCs. Prior work with this driver indicated that only text files could be transferred, and that the cost

transmission units (TRUs), character input/output, and connect time) was prohibitive. Since Dugout requires the transmission of binary files, Kermit was not benchmarked.

COPYPC

COPYPC is a proprietary file transfer protocol by McDonnell Douglas Corp. used with Tym/COMM on the PC. COPYPC automatically compresses and decompresses files to try to reduce the number of characters transmitted, but this works better on text files than binary files. COPYPC does not exhibit the same delays due to packet acknowledgement that XMODEM does. In addition, the TRUs used by this package are minimal, and the files transmitted are not modified. This package was implemented in the prototype version Dugout.

VISTA

Vista is a proprietary file transfer protocol by Control Data Corp. (CDC). Versions are available for IBM 370-style mainframes and several other host systems. The PC side is incorporated into the VistaCOM communications program. The protocol does not require 8-bit communications lines, and it incorporates a compression technique to automatically reduce the number of characters transmitted. The number of characters used to transmit files is comparable to COPYPC.

The number of TRUs required by the driver program to send or receive a file is much higher than either XMODEM or COPYPC. In particular, the cost to download files from mainframe to PC is significantly higher than the cost to upload files. This is not acceptable in Dugout since the primary direction of transfer is from the mainframe to many PCs. Also, the Vista program module is so large that the cost of just loading the program into memory in preparation for execution is significant.

The protocol uses a sliding window (several packets transmitted before acknowledgment), and it permits simultaneous bidirectional transfer of files, effectively doubling the line speed when files can be sent and received at the same time.

Although cost prohibits Vista from being an attractive alternative for Dugout, is has two potential advantages that may be valuable for future PAX applications:

- its simultaneous upload and download capability
- the use of file transfer queues to transfer many files in one session.

VI Product Summaries

Tym/COMM

Tym/COMM is a product of the McDonnell Douglas Corp., and is currently available in version 4.0. The package requires less than 50 Kbytes of disk storage—a relatively small amount of disk space on a user's PC.

Tym/COMM has a script language capability, which allows the user to name a sequence of commands and save them for future use, as in an automated logon sequence. This capability is not required by Dugout, but it may prove useful in other applications.

An escape sequence permits the execution of DOS commands and PC programs under mainframe control. Thus, Tym/COMM meets Dugout's requirements for automation and user-friendliness.

File transfer protocols supported by Tym/COMM are XMODEM and COPYPC. Under Tym/COMM, XMODEM transfers cannot be initiated from the mainframe, as required by Dugout. Thus, Dugout requires that Tym/COMM be used only with COPYPC.

Recommendation: Dugout users should continue to use Tym/COMM with COPYPC. It is cost-effective, easy to use, and meets all Dugout requirements.

ProComm

ProComm is a product of Datastorm Technologies, Inc., and occupies about 200 Kbytes of disk storage. It is currently available in version 4.2.

Like Tym/COMM, ProComm has a script language capability, but it does not support the execution of DOS commands under mainframe control. Since the execution of DOS or program commands cannot be controlled by the mainframe, ProComm cannot be fully automated within Dugout. While it would be possible to use ProComm with Dugout, a lack of automation would force users to perform the required operations manually. This is not desirable since it is tedious and vulnerable to error. Theoretically, scripts could be written to partially automate these operations. However, the scripts would not provide full automation, and error recovery would be cumbersome. Also, the support of different program versions would be untenable from a maintenance standpoint.

ProComm supports 12 file transfer protocols, but only XMODEM can be used from within Dugout. There are no mainframe drivers for the other protocols.

Recommendations: At this time, it is not recommended that ProComm be actively supported by Dugout. Although ProComm can operate with Dugout, other packages are more fully compatible with Dugout's environment and requirements.

VistaCOM

VistaCOM, a product of the CDC, is designed as a group of modules. VistaCOM is part of a larger series of communications tools offered by CDC. As installed in the configuration required to support Dugout, the modules occupy approximately 700 Kbytes of disk, which is relatively large for just a communications package.

VistaCOM has a script language capability. In addition, through the use of the VistaKIT product, VistaCOM can be incorporated into PC applications, providing extensive screen and communications capabilities.

While the VistaCOM program itself does not permit the execution of DOS commands and PC programs under mainframe control, another module supplied with the package does, enabling the product to be integrated with Dugout. The use of different modules is explained in user instructions, but some users may be confused since VistaCOM will not function properly with Dugout if the proper module is not running.

Two file transfer protocols can be supported under Dugout: Vista and XMODEM. The Vista protocol offers many sophisticated features not required by Dugout, and the operation cost is significantly higher than other alternatives. The XMODEM protocol can be used with Dugout, and the operating cost is roughly equivalent to the Tym/COMM-COPYPC combination.

Recommendations: Because VistaCOM is the standard communications program for a number of PAX users, it should be supported in Dugout using the XMODEM protocol. Dugout operations should be modified to transfer all files as archives to avoid XMODEM's character additions to transmitted files.

Also, because of the advanced capabilities of both VistaCOM and the Vista protocol, their use in other selected PAX PC applications should be explored.

ADDENDUM: Cost-Performance Benchmark Results

The COPYPC, Vista, and XMODEM file transfer protocols were tested for cost performance. The following charts show the benchmark results.

Chart 1: File Transfer Protocols Cost Comparison—TRUs

This chart shows the mainframe CPU component of file transfer costs. The Vista, XMODEM and COPYPC drivers were compared in the uploading and downloading of various-size files. The chart also shows TRUs expended versus the size of the file being transferred. Note that upload costs can differ from download costs within the same drivers. In particular, Vista download uses twice as many TRUs as Vista upload. Also, note that for all packages TRU usage is a linear function of file size.

Chart 2: File Transfer Protocols Cost Comparison—TIOs

Terminal input/output (TIO) is the number of characters required to transmit a file. The chart compares characters transmitted as a function of file size. Because the files used were binary, the text compression algorithms of Vista and COPYPC had no effect.

Chart 3: File Transfer Protocols Cost Comparison—Total Dollars

This chart compares total cost versus size of file transmitted. Total cost includes TRUs, TIOs, and connect time.

Charts 4 and 5: Cost Breakdown—Download and Upload

These charts illustrate the contribution of each cost component for four different-size files for the tested protocol drivers. (The smallest file transferred is the leftmost bar in each set of grouped bars; the largest file is the rightmost bar) Note that the original Vista (before performance enhancements were made for the Army) is included in these charts to show the relative improvement in tuning the driver for PAX. The download and upload costs are presented in two separate charts.

Charts 6 and 7: Benchmark Summaries—Download and Upload

Chart 6 contains download results and Chart 7 contains upload results. The protocol configurations tested were:

- XMODEM using Tym/COMM
- XMODEM using VistaCOM
- COPYPC using Tym/COMM
- The original Vista driver using VistaCOM
- The improved Vista driver using VistaCOM.

Each protocol driver was tested with six different files, which were a variety of types and sizes representative of those used in Dugout:

File 1—An archive containing a text document in compressed form (8191 characters)

File 2—The original unarchived text file that was used to generate File 1 (21606 characters)

File 3—An archive containing an executable PC program (21783 characters)

File 4—The original binary file that was archived to generate File 3 (51206 characters)

File 5—An archive of several files of mixed type (51206 characters)

File 6—An archive of several files of mixed type (150981 characters).

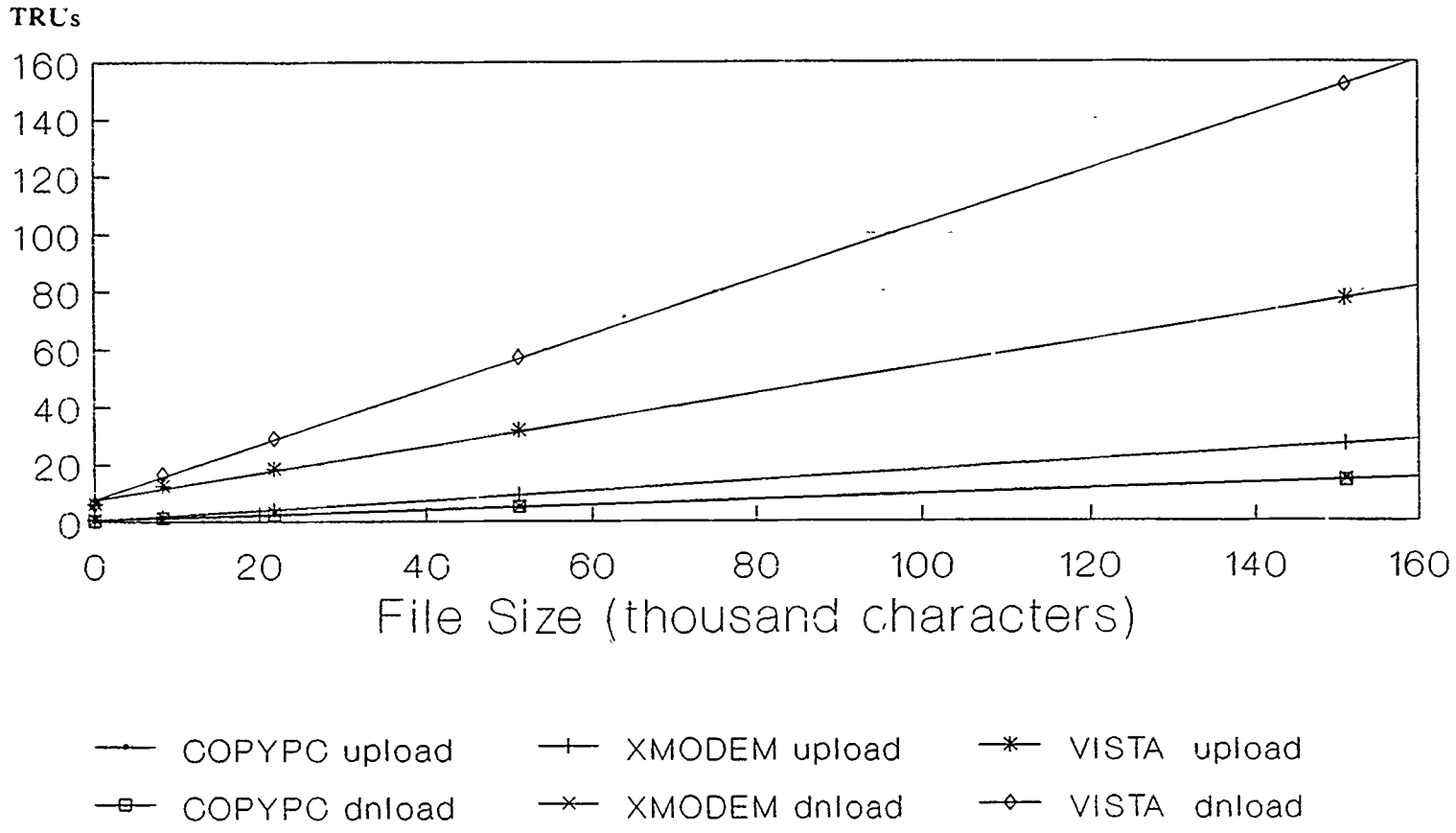


Chart 1: File Transfer Protocols Cost Comparison—TRUs

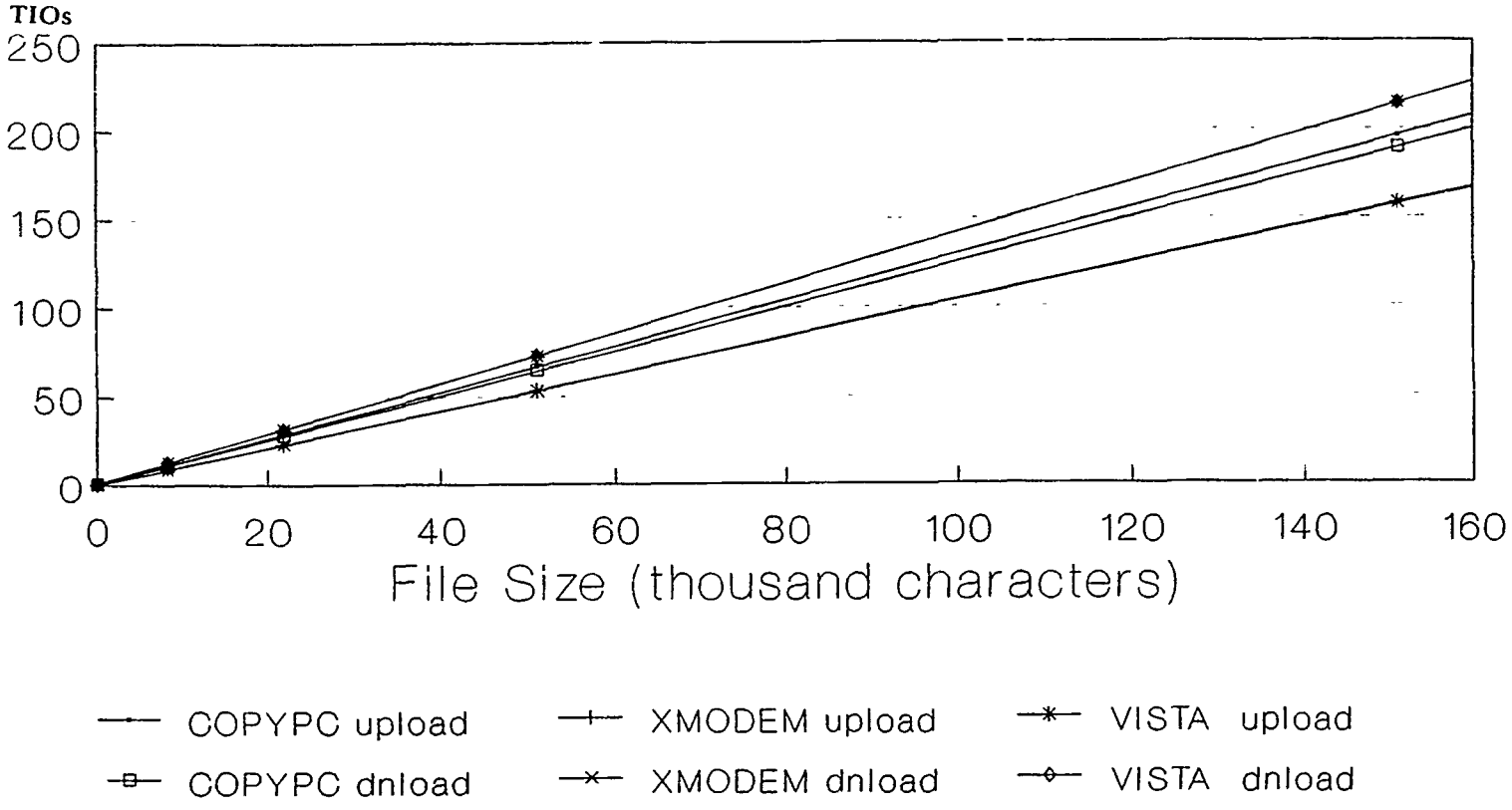


Chart 2: File Transfer Protocols Cost Comparison—TIOs

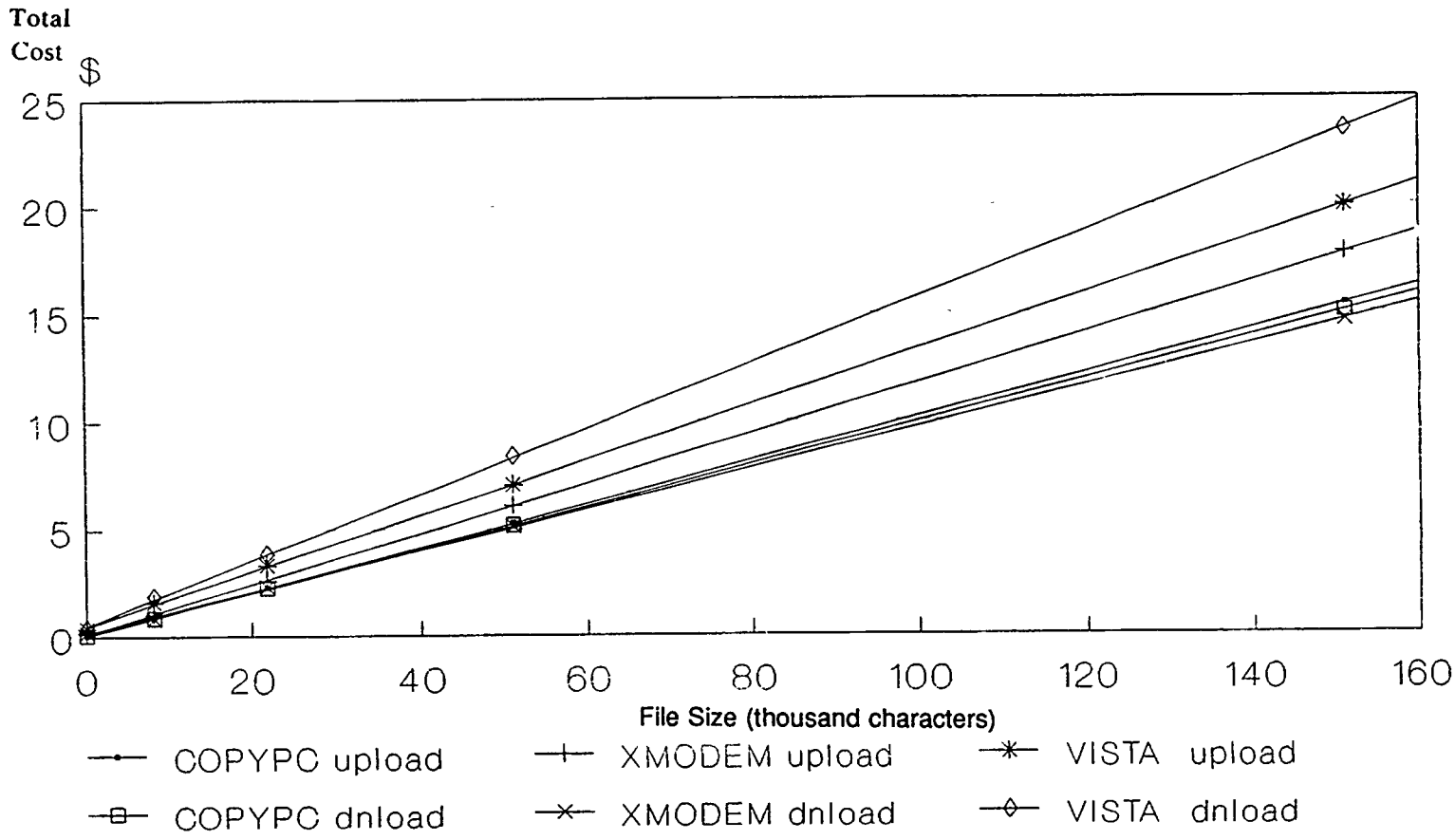


Chart 3: File Transfer Protocols Cost Comparison—Total Dollars

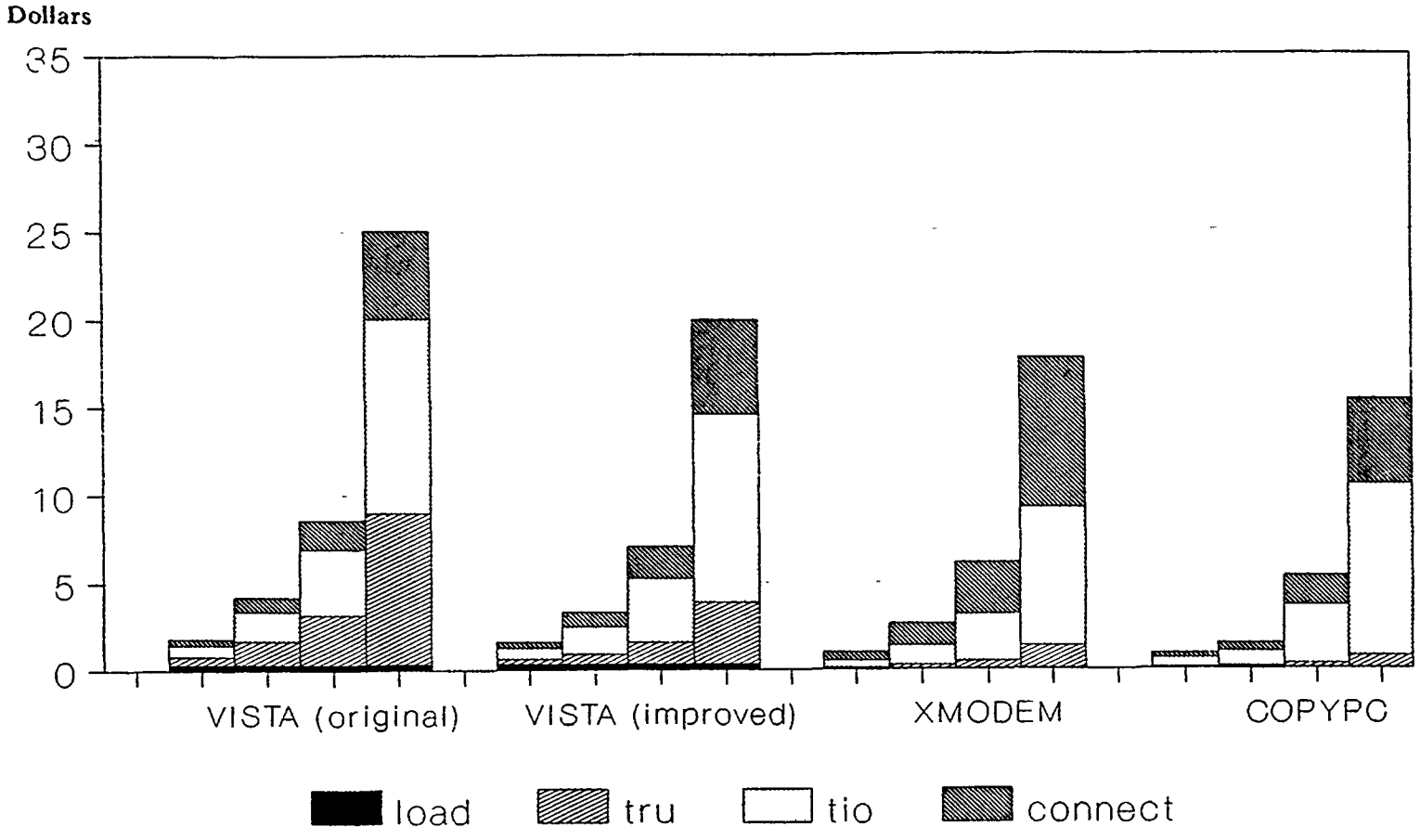


Chart 4: Download Cost Breakdown

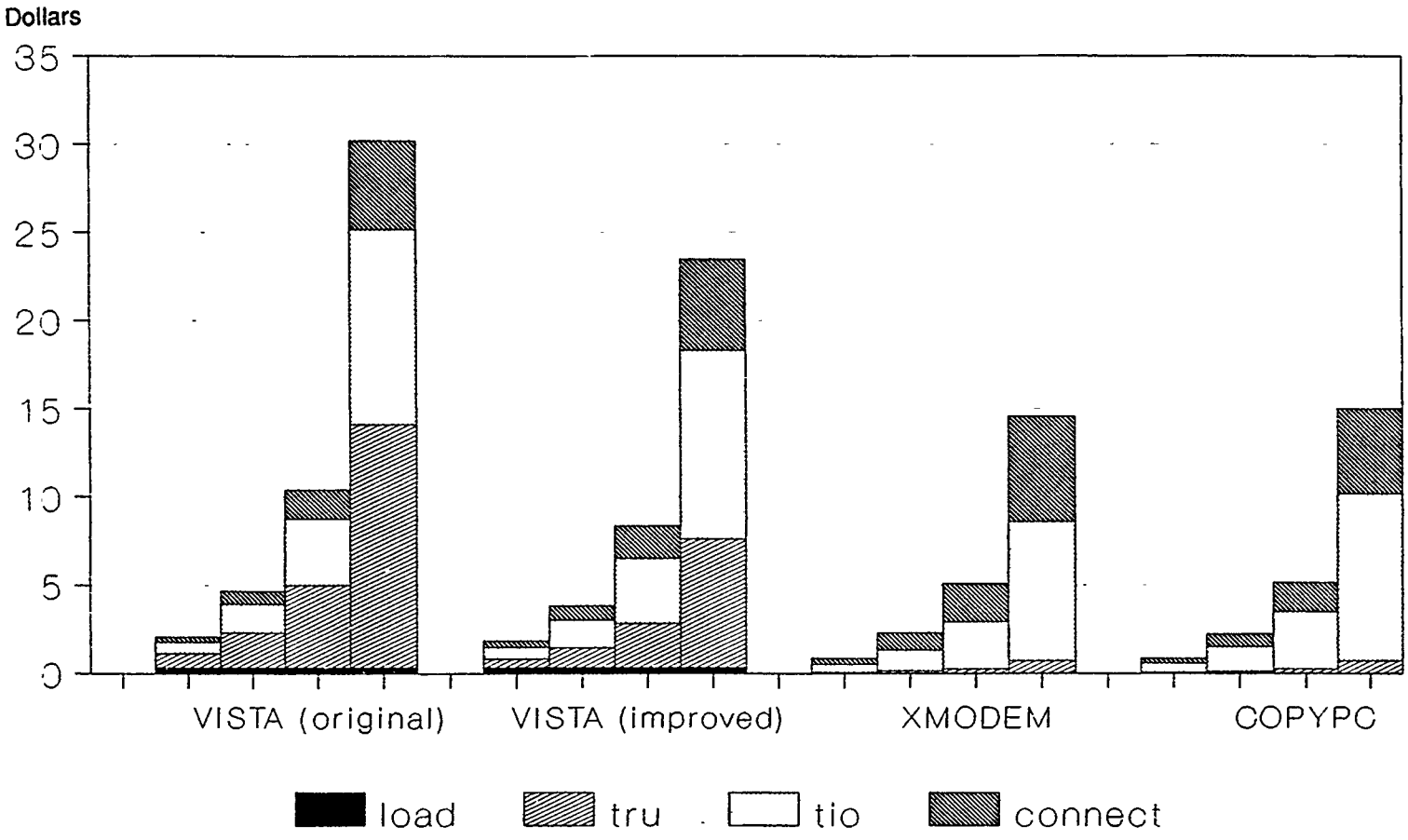


Chart 5: Upload Cost Breakdown

File Type	Size	Minutes	TRU	TIO	+----- Dollars -----			+-----
					conn	tru	tio	tot
XMODEM Download								
1 ARC	8191	2.0	1.16	8674	0.33	0.06	0.43	0.82
2 DOC	21606	5.3	2.72	22773	0.88	0.14	1.14	2.16
3 ARC	21783	6	3	23000	1.00	0.15	1.15	2.30
4 EXE	27731	7.0	3.02	29024	1.17	0.15	1.45	2.77
5 ARC	51206	12.0	5.16	53230	2.00	0.26	2.66	4.92
6 ARC	150981	35.0	14.31	157105	5.83	0.72	7.86	14.41
VistaCOM-XMODEM Download								
1 ARC	8191	2	1.3	8715	0.33	0.07	0.44	0.84
2 DOC	21606	5	2.8	22813	0.83	0.14	1.14	2.11
3 ARC	21783	6	3.1	22946	1.00	0.16	1.15	2.31
4 EXE	27731	7	3.1	29064	1.17	0.16	1.45	2.78
5 ARC	51206	13	5.3	53270	2.17	0.27	2.66	5.10
6 ARC	150981	36	14.4	157143	6.00	0.72	7.86	14.58
COPYPC Download								
1 ARC	8191	1.6	1.22	10650	0.27	0.06	0.53	0.86
2 DOC	21606	2.7	2.78	17131	0.45	0.14	0.86	1.45
3 ARC	21783	4.5	2.32	27629	0.75	0.12	1.38	2.25
4 EXE	27731	5.0	2.86	33320	0.83	0.14	1.67	2.64
5 ARC	51206	10.0	5.2	64606	1.67	0.26	3.23	5.16
6 ARC	150981	29.0	14.12	189001	4.83	0.71	9.45	14.99
VistaHOST Download								
1 ARC	8191	1.7	22.32	13221	0.28	1.12	0.66	2.06
2 DOC	21606	2.5	27.07	18000	0.42	1.35	0.90	2.67
3 ARC	21783	4.3	46.49	32293	0.72	2.32	1.61	4.65
4 EXE	27731	5.0	50.00	33800	0.83	2.50	1.69	5.02
5 ARC	51206	10.0	99.80	75231	1.67	4.99	3.76	10.42
6 ARC	150981	30.0	282.26	221637	5.00	14.11	11.08	30.19
VistaCOM Vista pcpack Download								
1 ARC	8191	2.3	16.54	12849	0.38	0.83	0.64	1.85
2 DOC	21606	3.0	21.58	17740	0.50	1.08	0.89	2.47
3 ARC	21783	4.8	29.12	31324	0.80	1.46	1.57	3.83
4 EXE	27731	5.2	30.55	32744	0.87	1.53	1.64	4.04
5 ARC	51206	11.2	57.08	72799	1.87	2.85	3.64	8.36
6 ARC	150981	31.2	151.82	214227	5.20	7.59	10.71	23.50

Chart 6: Download Benchmark Results

File	Type	Size	Minutes	TRU	TIO	+----- dollars -----+ conn	tru	tio	tot
XMODEM Upload									
1	ARC	8191	3.0	2.00	8679	0.50	0.10	0.43	1.03
2	DOC	21606	8.0	5.44	23394	1.33	0.27	1.17	2.77
3	ARC	21783	8.0	4.10	22910	1.33	0.21	1.15	2.69
4	EXE	27731	10.0	5.09	29307	1.67	0.25	1.47	3.39
5	ARC	51026	18.0	10.68	53236	3.00	0.53	2.66	6.19
6	ARC	150981	43.0	26.36	157109	7.16	1.32	7.86	16.34
VistaCOM-XMODEM Upload									
1	ARC	8191	3.0	1.70	8781	0.50	0.09	0.44	1.03
2	DOC	21606	8.0	5.00	22746	1.33	0.25	1.14	2.72
3	ARC	21783	7.5	4.33	23039	1.25	0.22	1.15	2.62
4	EXE	27731	10.0	5.09	29307	1.67	0.25	1.47	3.39
5	ARC	51206	17.5	9.45	53441	2.92	0.47	2.67	6.06
6	ARC	150981	51.0	26.82	157602	8.50	1.34	7.88	17.72
COPYPC Upload									
1	ARC	8191	1.7	1.42	10719	0.28	0.07	0.54	0.89
2	DOC	21606	2.7	3.05	18009	0.45	0.15	0.90	1.50
3	ARC	21783	4.3	2.62	28700	0.72	0.13	1.44	2.29
4	EXE	27731	5.0	2.93	34670	0.83	0.15	1.73	2.71
5	ARC	51206	10.0	5.29	66974	1.67	0.26	3.35	5.28
6	ARC	150981	29.0	14.41	195793	4.83	0.72	9.79	15.34
VistaHOST Upload									
1	ARC	8191	1.9	16.42	13154	0.32	0.82	0.66	1.80
2	DOC	21606	3.0	20.51	17933	0.50	1.03	0.90	2.43
3	ARC	21783	5.0	30.70	32229	0.83	1.54	1.61	3.98
4	EXE	27731	5.0	33.46	33733	0.83	1.67	1.69	4.19
5	ARC	51206	10.0	63.30	75164	1.67	3.17	3.76	8.60
6	ARC	150981	30.0	179.66	221646	5.00	8.98	11.08	25.06
VistaCOM Vista pcpack Upload									
1	ARC	8191	2.0	12.60	12776	0.33	0.63	0.64	1.60
2	DOC	21606	3.0	16.61	17629	0.50	0.83	0.88	2.21
3	ARC	21783	4.9	18.37	31212	0.82	0.92	1.56	3.30
4	EXE	27731	5.0	19.36	32669	0.83	0.97	1.63	3.43
5	ARC	51206	11.0	31.78	72687	1.83	1.59	3.63	7.05
6	ARC	150981	32.1	77.09	214114	5.35	3.85	10.71	19.91

Chart 7: Upload Benchmark results

ABBREVIATIONS AND ACRONYMS

ASCII	American Standard Code for Information Exchange
CAPCES	Construction Appropriation, Programming, Control, Execution System
CDC	Control Data Corp.
CRC	cyclical redundancy check
DBMS	database management system
DC	Dugout coordinator
DOS	Disk Operating System
EBCDIC	Extended Binary-Coded Decimal Interchange Code
MCA	Military Construction, Army
MYPLAN	Automated Multi-Year Plan Application Subsystem
PAX	Programming, Administration, and Execution
PAXID	PAX login identification
PC	personal computer
PCDID	PC Dugout login identification
RAM	random access memory
REXX	Restructured Extended Executor
SAA	Systems Application Architecture
SQL/DS	structured query language/data system
TRU	transmission unit
USACE	U.S. Army Corps of Engineers
VM/CMS	Virtual Machine/Conversational Monitor System

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